MYOCARDIAL TAGGING DURING REAL-TIME MRI

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Abstract- **The advent of high performance gradients and parallel imaging schemes has made real-time MRI a stable mode of scanning. Cardiac tagging techniques have been shown to give extremely precise and accurate estimates of the evaluation of myocardial function. We have implemented a real-time mode of MRI that allows myocardial tagging to be performed without breath-holds, or gating. This will make the quantitative evaluation of myocardial function simpler in those patients with arhythmias and those who cannot hold their breath.**
Keywords - **MRI, cardiac imaging, tagging, real-time.**

I. INTRODUCTION

The purpose of this study was to demonstrate the ability to perform quantitative evaluation of myocardial function while scanning in a real-time mode, with no gating and no breath-hold. Previously, myocardial tagging studies have been acquired using segmented data acquisitions over 3-20 heartbeats during a patient breath-hold. These studies provide excellent evaluation of myocardial function by measuring quantitative parameters such as regional myocardial shortening and left ventricular twist [1]. However, in some patients, the acquisition of a stable ECG trigger is time consuming. Also, the procedure of asking the patient to repeatedly suspend respiration adds to the examination time, and the inconvenience. The goal of this work was to produce images of sufficient quality to measure function quantitatively without the need for cardiac gating or breath-holding.

II. METHODOLOGY

A segmented gradient echo pulse sequence with an echo-train readout was used to obtain the real-time images [2,3]. The following parameters were used: TR=10ms, 8 echoes per TR, FOV= 280 x 140, XRES=128, readout bandwidth = +-125kHz, 16 k_y lines below k_y=0, 24 k_y lines above k_y=0. This sequence yields images with a pixel dimension of 2.2mm x 1.5mm, at the rate of 20 frames per second.

A tagging pulse was added to this pulse sequence. The tagging pulse comprised 5 non selective rf-pulses with duration of approximately 10 milliseconds and relative amplitudes of 3,4,5,4,3. Between each tagging pulse, a triangle gradient was used to generate the phase accumulation perpendicular to the tag plane direction, and a large crusher gradient was used to kill stimulated echoes from the tagging pulses.

While tags can be inserted into the real-time sequence at any time, we chose to synchronize them to a single R-wave trigger from an ECG. Other potential triggers for the tagging pulse could be the peripheral gating input or an operator controlled trigger button. The synchcronization of the tagging pulse is obviously beneficial when reviewing multiple slices of the heart. The pulse sequence automatically stepped through multiple slices of the heart from the base to apex.

For demonstration purposes, a 20 kg dog was imaged while lying in the supine position. The dog was ventilated and anesthetized with isoflurane; the heartrate was approximately 100 beats per minute. The 4 coil cardiac phased array receiver was placed around the chest and EKG leads were placed on the chest. All imaging was performed under protocols approved by the NIH animal care and use committee.
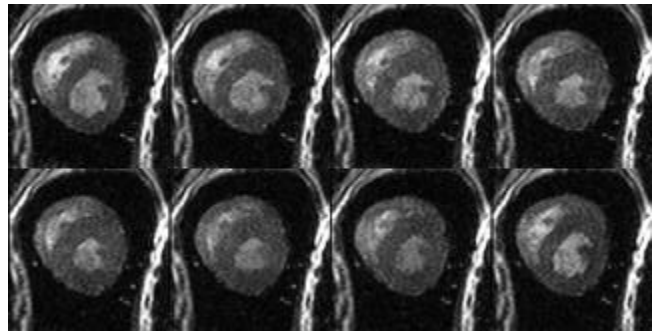
III. RESULTS

Figure 1 A non-tagged real-time sequence of cardiac images obtained in the dog heart.

Figure 1 shows individual frames from a movie sequence of cardiac images obtained with this sequence without the addition of tagging pulses. Note the excellent resolution of the endocardial wall. The high contrast between the myocardium and the ventricular blood make these data perfectly suitable for determination of global mechanical function such as ejection fraction. Figure 2 shows the same slice with the addition of the tags, triggered from a single R-wave. The deformation of the tags is clearly visualized, and there is little tag blurring. The restriction of placing the tags perpendicular to the readout gradient helps to minimize the tag blurring from motion [1]. For this demonstration the pulse sequence was set to scan each slice for two seconds; hence, all of the 1D tagging data from 7

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Figure 2 Real-time short axis images of the dog heart obtained with tags.

Figure 3: Real-time long axis images of the dog heart obtained with tags.

slices was obtained within a total scan time of 14 seconds. In each of the movies of the slices, the tags persisted for close to two heartbeats. Figure 3 shows the long axis images obtained from the same sequence. While these data are not of the same quality as that obtained using breath-holding, and multiple acquisitions gated to the ECG, the ability to discriminate normal from abnormal function on a regional basis is clear.

IV. DISCUSSION

We have demonstrated the ability to obtain tagging data during non-gated, non-breath-hold acquisitions. The application for this sequence will be in those patients that do not yield a good ECG gate, or those who cannot hold their breath. In many clinical cases simple real-time cardiac CINE will be sufficient to identify regions of abnormal wall function. However, in some cases, where subtle functional changes require a quantitative probe such as MR tagging, the method presented here will be of value. It is conceivable that with real-time tagging, a complete 7 slice exam of cardiac function could be obtained in 15-30 seconds without the need for cardiac gating or patient breath-holds. If a slice is obtained with unacceptable image quality because of breathing, coughing or ectopic beats, it can be scanned again immediately.

REFERENCES

[1] E.R. McVeigh: *MRI of myocardial function: motion tracking techniques.* Magn. Reson. Imag. 14(2), 137-150, (1996)

[2] S.B. Reeder, E.A. Atalar, A.Z. Faranesh, E.R. McVeigh: *Multi-echo segmented k-space imaging: an optimized hybrid sequence for ultra-fast cardiac imaging.* Magn. Reson. Med. 41(2):375-385, (1999)

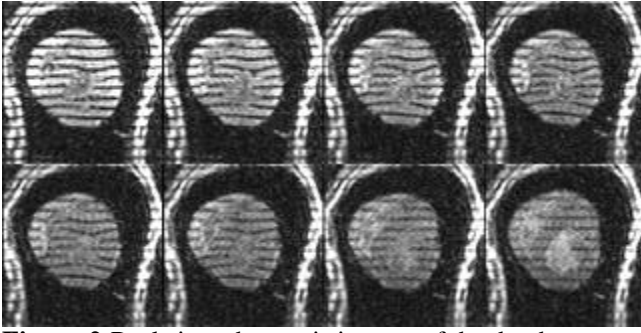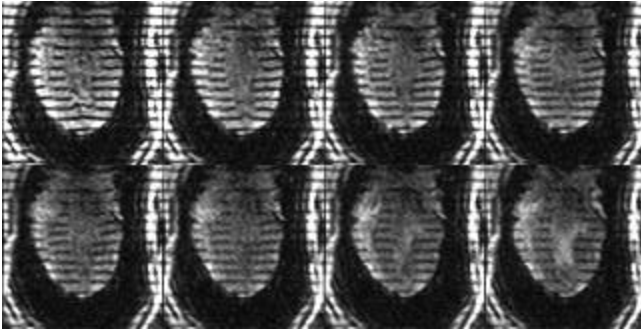[3] F.H. Epstein, S.D. Wolff, A.E.Arai. Segmented *k*-Space Fast Cardiac Imaging Using an Echo-Train Readout. *Magn. Reson. Med.* 1999; 41:609-613.